# Integrating a Hydrogen Energy Station into a Federal Building

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## Objectives

- Evaluate combined fuel cell power/hydrogen production systems (Energy Stations):
  - Analyze energy station systems with 50-kW proton exchange membrane fuel cells (PEMFCs) that are suitable for installation in Federal buildings
  - Analyze options for system components, including direct hydrogen and reformate fuel cells and various storage, power production, and hydrogen usage configurations
  - Determine costs and energy efficiency for different system configurations
- Assess integration with buildings and potential for cogeneration:
  - Analyze potential for heat recovery from fuel cell/hydrogen production systems
  - Identify potential for cogeneration in Federal building applications
- Identify potential fleets for vehicle operation
- Establish partnerships for hydrogen fueling and power sales
- Identify barriers to hydrogen use
- Make recommendations for future development
- Identify potential opportunities to develop fuel cell energy stations

## Technical Barriers

This project addresses the following technical barriers from the following sections of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

- Hydrogen Production
  - B. Operation and Maintenance (O&M)
  - E. Control and Safety
- Hydrogen Storage
  - V. Life Cycle and Efficiency Analyses
- Fuel Cells
  - F. Heat Utilization
- Technology Validation
  - C. Hydrogen Refueling Infrastructure
  - I. Hydrogen and Electricity Coproduction

- Education
  - B. Lack of Demonstrations or Examples of Real World Use

### Approach

- Analyze integrated power and fueling system
- Explore private and public partnerships
- Identify barriers to hydrogen use

### Accomplishments

- Developed list of possible components that will comprise hydrogen generation and dispensing stations
- Developed list of relevant system configurations from possible components, with detailed description and schematics of proposed system configurations
- Selected a baseline system configuration, and initiated a detailed system cost and performance analysis
- Prepared comprehensive list of potential operating configurations
- Surveyed potential public/private fleets and Federal buildings for siting a hydrogen energy station
- Initiated evaluation of building integration and prepared comprehensive list of potential building interfaces
- Determined and contacted sites best suited for hydrogen energy station
- Created general process flow diagram (PFD) representing potential hydrogen energy station fluid/ energy flows for target site system
- Evaluated emissions benefits for hydrogen energy station operation relative to conventional energy sources

### Future Directions

- Continue the analysis and identification of energy station applications at target sites
- Analyze the cost, emissions, and energy utilization benefits of integrated power and fueling for specified site
- Identify the key technology, cost, and public perception barriers to hydrogen use
- Make recommendations for future development

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## Introduction

The purpose of this technical analysis is to evaluate potential synergies between transportation and stationary applications to accelerate development of a hydrogen infrastructure through the installation of 50-75 kW stationary fuel cell-based energy stations at Federal building sites. The various scenarios, costs, designs and impacts of such a station are quantified in a cost-shared project that utilizes a natural gas reformer to provide hydrogen fuel for both the stack(s) and a limited number of fuel cell powered vehicles, with the possibility of using cogeneration to support the building heat load.

## Approach

To carry out this analysis project as effectively as possible, TIAX structured it to consist of six major tasks. During the first phase of the project (FY 2002), TIAX completed the first three tasks. During the second phase of the project, TIAX will use the results from the first phase to complete the following three tasks.

Task 4 — Analyze Integrated Power and Fueling. This task involves a more detailed analysis and modeling of the technologies and system designs that were selected in Task 1. This analysis will evaluate and quantify the costs, emissions, energy flows, number of vehicles to be fueled, and optimal fueling and storage time for each of the selected systems and technologies.

Task 5 — Explore Private and Public Partnerships. This task involves contacting potential public/private partnerships to determine their interest/plans to engage in such ventures. Part of this investigative process will be to determine existing and planned public/private partnerships and undertakings related to the development of a hydrogen fueling infrastructure, and to evaluate their success.

Task 6 — Identify Barriers to Hydrogen Use. TIAX will make an assessment and analysis of the different types of barriers and obstacles with which the development of a hydrogen infrastructure will be faced, including: key technological hurdles, cost obstacles, policy barriers and needed changes, and public perception issues.

## Results

During FY 2003, the following items were accomplished under Task 4: Analyze Integrated Power and Fueling Systems. We began to evaluate and quantify the emissions, costs, and energy flows for each of the selected systems and technologies. Figure 1 shows a projection of annual greenhouse gas (GHG) emissions for a hydrogen energy station supporting passenger vehicles and providing electricity and heat for a building. As indicated, the GHG emissions associated with supporting a comparable gasoline vehicle and the equivalent heat and electricity demand for the building using utility gas and electricity are twice that of the emissions from a hydrogen energy station supporting the same energy demand. Figure 2 shows a projection of annual criteria pollutant emissions (i.e., $NO_x$, CO, and hydrocarbons) for the same cases. Under this comparison, operating a comparable gasoline vehicle and producing the same level of building energy from utility gas and electricity generates 20 times the criteria pollutant emissions generated by a hydrogen energy station.

Figure 3 shows a sample cost curve for fuel cell stacks. These curves indicate the relationship between stack production volume and cost per kilowatt. This and similar cost profiles are being developed to facilitate an overall cost projection of energy stations infrastructure under both small and large volume production scenarios.

Figure 4 provides a sample PFD. PFDs are being generated for the target energy station configurations to model energy flows between major system components. This modeling process facilitates system optimization by indicating component

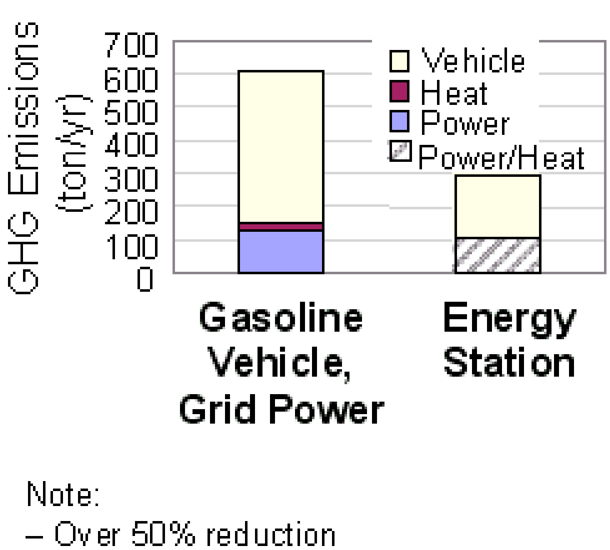


**Figure 1.** Annual Greenhouse Gas Emissions

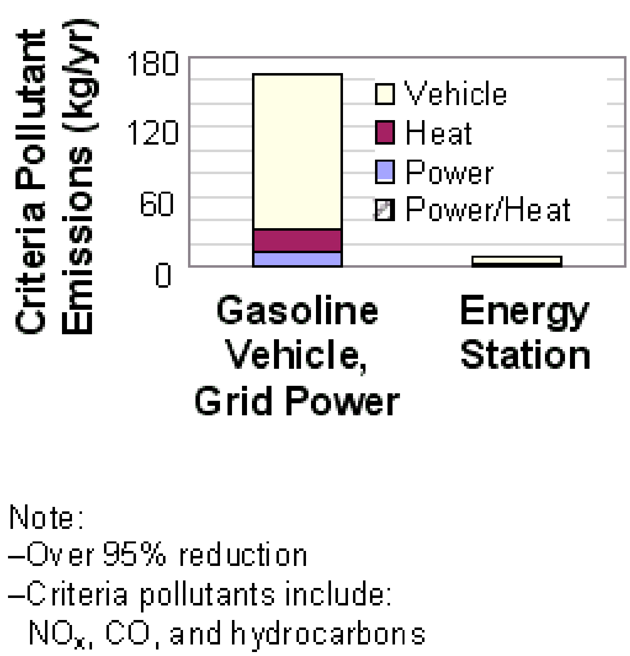


**Figure 2.** Annual Criteria Pollutant Emissions

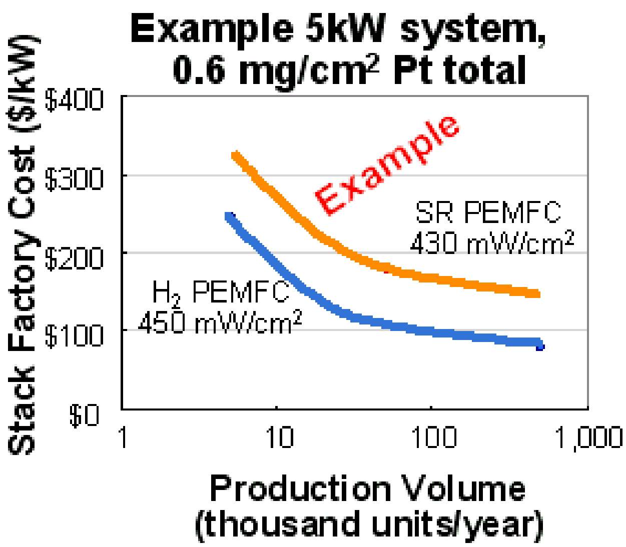


**Figure 3.** Example Fuel Cell Stack Cost Curves

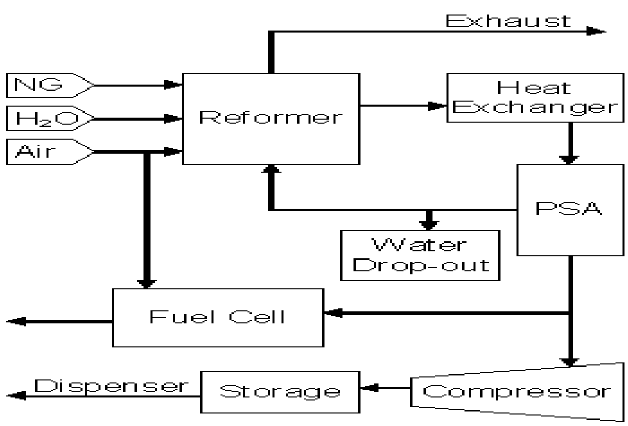


**Figure 4.** Example Process Flow Diagram

capacity requirements under a desired energy output. Once the system component sizing has been determined, the cost of particular components and of the overall system can be determined.

## Conclusions

- TIAX has identified a set of representative technologies and representative operational scenarios that are being analyzed to estimate the size, power output, and cost of a hydrogen energy station at a target site.
- Hydrogen energy stations provide significantly lower GHG and criteria pollutant emissions compared to equivalent conventional vehicle and building operation.
- System optimization of an integrated hydrogen energy station will take into account system operation, capacity, and cost.